

poisons], for it has a very delicate stomach, and, I believe, cannot vomit; at any rate, does not readily do so." There is room for an extended biological and psychological study of the rat, for it does seriously affect the commerce of the world both directly as a consumer and indirectly as the international carrier of plague.

Perhaps the most fascinating item of the congress programme was the popular lecture by Prof. Mellanby, of Sheffield, on "Vitamins." A health congress without a discussion on diet would be a solecism, and to-day the whole theory of diet has been transfigured by the "vitamin" hypothesis. It is well to regard the word as provisional, for in this way the methods of research are likely to remain more fluid. No one has established a better right than Prof. Mellanby to be heard on the recent developments. He set forth the data with persuasive lucidity. He showed that experiment discredited the old view that diet could be exhaustively expressed in terms of proteins, carbohydrates, fats, salts, and water. There is a *sextum quid*. From Eyckman's discovery that beri-beri was due to rice robbed of certain portions by "polishing" to the latest experiments with puppies

to show the production and arrest of rickets, Prof. Mellanby made clear the reasons for assuming the existence of the three factors: Fat-soluble A, water-soluble B, and the anti-scorbutic factor. The work of Prof. Mellanby and his wife in this field is well known to the technical and official public, but there is much need to spread the ascertained facts among the wider public, for this is the only way to generate sufficient pressure to secure that the consumer shall have the benefit of the latest discoveries. The fact that hypotheses are disputed is no reason for not making them known. In this matter the facts even as now ascertained are of high practical value. The physiological and biochemical departments of the various schools ought to work in more intimate touch with the administrative public, especially with the clinical investigators.

Of the congress as a whole it can be said truly that the mayor and councillors did everything to show that they understood the importance of the institute's educational work, and as we parted in the clean air and light of a perfect summer day we assured each other that on the scientific, as well as on the social, side it had been "a very nice congress."

The Importance of Research in the Development of the Mineral Industries.¹

By SIR RICHARD REDMAYNE, K.C.B.

THE present state of the civilised world is, economically, paradoxical. The need for commodities is very great, yet the production of them is so costly that industry is languishing for lack of orders. On the termination of the war, after four years of excessive waste and destruction, the world is found short of houses, food, and other commodities; railways and rolling stock are in sad need of repair, restoration, and expansion; the output of fuel, the life-blood of our economic existence, is greatly decreased, and the mines from which it is produced are in a backward state of development.

The cessation of hostilities was succeeded almost at once by a period of feverish industrial activity—it would be erroneous to apply the words "general prosperity"—followed by a cycle of great depression. The demand for goods is great, but production is falling. What is the explanation? It lies, I think, in a combination of circumstances:—

(1) A feeling of insecurity due to unsettled political and financial conditions. Hence a disposition to conserve rather than to utilise in commercial ventures such capital as is available.

(2) The incidence of rate of exchange.

(3) The high cost of production consequent on the high cost of living and the higher standard of comfort demanded (and rightly demanded) by the labouring classes than formerly obtained.

(4) The lower, and still apparently decreasing, productive power of labour.

The first two conditions will in part right themselves in process of time as the various political problems are solved, or partly solved, and rates of exchange will then tend towards the normal; but a very great deal depends upon the last two conditions, as the future position of production is not easy to forecast. Higher and cheaper production is a difficult desideratum to obtain in view of the high rate of wages now ruling and the diminishment in working time either achieved or claimed by the manual workers of the day, and these are demands which are not likely to show much abatement in the future. What is the

solution? The answer I venture to give, the solution which I presume to propound, to this problem, is "research." To discover by research cheaper means of production, and by research to create new outlets.

The object, then, of my address to-day is to direct attention to the necessity for research work in the mineral industries. Let me make more clear what I have in mind by taking one special case in point, a most important case—that of coal. It is an axiom that a cheap and plentiful supply of suitable fuel is necessary for our prosperity as a manufacturing country. This situation will remain, and is bound to remain, until some other means of producing power cheaply is discovered.

I think it may be taken that, roughly speaking, the rate per cent. of return on the capital invested in coal-mining in Great Britain over the last hundred and fifty years has, on the average, not varied much—reckoning in, say, periods of ten years—yet the progress made during the last two or three generations in every respect, except in the rate of return on capital, has been enormous.

Thus such everyday features of a colliery working at the present time as shaft cages and guides, the safety lamp, the steam locomotive, the trade in coke and by-products, ventilating fans, wire ropes, mechanical haulage, mechanical screening, the use of compressed air, the application of electricity to signalling, lighting, and motive power, and the mechanical cutting of coal have all been introduced in the course of the last hundred and twenty years. There is scarcely an appliance (save the simplest tools) or a machine in use at a modern colliery which could have been made at the beginning of the nineteenth century; and during this period the wages of the workmen—I omit the war period and the present abnormal time from consideration—have been increased certainly between 200 and 300 per cent., and this though the price of coal did not greatly increase; as a matter of fact, between the years 1828–1900 the variation was small and the price was lower in the latter year than in the former.

It was *because* of the improvements introduced into coal-mining that it was possible to keep down the

¹ Address delivered at the annual meeting of the British Science Guild held at the Goldsmiths' Hall on June 8.

cost of production, allowing of an increasing trade being done and the maintenance of a fair return on the capital invested in the industry. Further improvements are, to my mind, the only satisfactory solution to our present economic difficulties. Let me repeat: Lessen the cost of production by applying new methods, the result of research, and by research discover extended and new uses for minerals. Let me briefly indicate examples of possible research work in the mineral industry.

Coal—mineral fuel—naturally occurs at once to the mind. I am one of those who believe that the cost of production can be reduced by the wider application of the most up-to-date methods of the "getting" of the coal, in the transport and usage of the coal, but I doubt very much, even if and when these methods are applied to the fullest extent practicable, whether it will be possible to reduce the price to quite the pre-war level.

In some of our largest industries coal, next to wages, is the highest item of cost. The way of research, therefore, appear to lie along the lines of the more efficient use of coal.

We know in the smelting of Cleveland iron in Yorkshire under present methods that about 74 per cent. of the total available heat of the fuel used is usefully applied, which for economy of smelting large quantities of iron is a remarkable result to have achieved. But is it beyond the bounds of possibility to reduce the consumption of one ton of coke to produce one ton of iron? And, as was pointed out by the Coal Conservation Committee in their final report of 1918, the economy of fuel which would result from the combination in single units of coke-ovens, blast furnaces, steel furnaces, and rolling mills would be very great indeed. The idea was foreshadowed in Belgium and Germany in the early years of the present century, and in 1910 Mr. T. C. Hutchinson, in his presidential address to the Cleveland Institution of Engineers, expressed the view "that the time would shortly come when ironstone would be brought in at one end of the works and finished steel would be turned out at the other, only such coal being used as was required for the coke-ovens to make sufficient coke to smelt the ironstone." In 1913 Mr. Hutchinson repeated this belief at the Brussels meeting of the Iron and Steel Institute, and in 1912, in his presidential address to the Iron and Steel Institute, Mr. Arthur Cooper also expressed the belief that the time was close at hand when the iron and steel industries would be forced by the stress of competition to adopt this reform.

The economic utilisation of low-grade fuels is a matter of great moment. There are in the United Kingdom, as in all coal-producing countries, vast quantities of coal which it does not pay to work owing to the low price realisable thereon. Probably the use of so-called colloidal fuel offers a solution, and will render the use of these low-grade coals practicable and profitable; for very fine coal mixed in about equal quantities with fuel oil produces a fuel which can be burnt in the same way as oil, and, bulk for bulk, though not weight for weight, gives in thermal values results equivalent to those of the fuel oil alone.

The recovery of coal and its more perfect cleaning by the froth flotation process, for some years applied to the recovery of metalliferous ores from their associated gangue, presents features of interest and probable profitable results.

The low-temperature carbonisation of coal, too, is at present occupying the minds of many investigators and may lead to the more extensive use of low-grade fuels. But to be commercially successful such a process should be continuous, and the resultant fuel capable of being sold at a price below that of coal.

Oil Shale.—The stores of liquid mineral oil will not last for ever; indeed, it is probable that the next fifty years will see, if not the exhaustion of this source of oil, a great reduction in the supplies available. We must turn, therefore, towards distillation of oil-bearing mineral—oil shales and coal—to take the place of our present petroleum supplies. Although there are very few retorts erected in the United States for the treatment of oil shale, and such as are being applied to experimental purposes only, yet even that country of oil supplies is turning its attention to the consideration of its oil-shale potentialities. Research work would naturally be directed towards the economic desulphurisation of the oil and the minimising of losses in refining, so allowing of oil shales being worked which at present cannot be made available. The loss in refining oil from Scotch oil shale is about 23 per cent. of the crude oil treated, as compared with a loss of 3½–4 per cent. only in the case of straight-run refining of American petroleum. The process of refining is the process of getting rid of offensive substances, but in those cases where refinement results in such high losses, as in the case of shale oil, it is probable that other than the objectionable substances are lost—substances which might be retained with advantage in the finished product.

Iron.—I have already alluded to the cheaper reduction of iron ores. The available reserves of high-grade iron ores in Great Britain are vastly nearer exhaustion than are the coal supplies. More and more, too, the world will have to turn to the poorer grade of ore—a wide field is here offered for research work in devising economic methods for their reduction. The economic smelting of ferruginous sands, in which connection may be mentioned those of Sweden and New Zealand, has so far defeated the efforts of metallurgists, rich in iron though these sands are.

In connection with blast furnaces, two products, the possible recovery of which is worth investigation, are those contained in the dust in the gases, namely, iron and potash; these dusts contain a high percentage of iron.

The possible economic recovery of vanadium, a mineral much in request in respect of the manufacture of a certain class of steel, from ashes of carbonaceous substances has been mooted.

Minerals Used to Harden Steel.—In respect of several minerals which until of late years were unimportant, or comparatively so, an important use has been found in connection with steel. One of these is tungsten. Tungsten metal powder is, as all metallurgists know, required for the manufacture of high-speed tools. The position in respect of tungsten is one which is at present exercising the minds of those interested in its extraction from wolfram; the business is now practically unprofitable. During the war high-speed steel was in great demand; now the demand has fallen away. Cannot new uses be found for tungsten? I have heard that the metal can be used for making piano-strings. The application of tungsten to branches of industry other than to steel offers a fruitful field for research.

I incline to the belief that, given a cheap and abundant production of some of the minor metals, uses will be found for them; and, conversely, with the discovery of uses enhanced production will be forthcoming. A case in point is the recent development in the production of stainless cutlery, which is made of chromium steel, and is in process of providing an important outlet for supplies of chromium ore.

Probably 95 per cent. of the world's production of manganese ores is used directly or indirectly in the manufacture of iron and steel. Self-hardening steels, made before the development of "high-speed tool

steels," contained from $3\frac{1}{2}$ to 4 per cent. of manganese. Nickel steels containing from 5 to 6 per cent. of manganese and from 20 to 25 per cent. of nickel have been largely used for many years for electrical resistance wires. But the output has fallen away considerably. India is now our great source of supply of manganese. The output from that country was, however, for 1919 only about five-eighths of that for 1913, and the cost of production has greatly increased owing to the increased rate of wages demanded by the native labourers. The rupee exchange and high freights also hamper the export trade. The value of the ore for metallurgical purposes, as indeed in the case of the ores of nearly all metals, depends on three factors:—

- (1) The percentage of the metal contents (the metals in the case of manganese being manganese and iron).
- (2) The percentage of the impurities (which in the case of manganese are phosphorus, silica, alumina, copper, cobalt, lead, zinc, barium, etc.).
- (3) The physical condition in which the material is delivered to the furnace.

There are fairly extensive deposits of low-grade and impure manganese ores which research might render available, if not for metallurgical, then for chemical uses.

The position of zinc is interesting. The British zinc industry is in a very depressed state, and to this matter the Imperial Mineral Resources Bureau has been devoting much anxious thought. The Bureau was fortunate in having the benefit of the views on this subject of Mr. Gilbert Rigg and other well-known experts. Mr. Rigg, in a paper which he contributed on the subject of the position of the zinc industry at the close of 1919, points to the successful application of the electrolytic reduction of zinc ores in the face of much scepticism as to its commercial possibilities, and concludes his paper with these words:—"What is going to be the position of England's spelter industry in the next five years? If we are going to compete successfully, having regard to the high cost of fuel and materials and high cost of labour and labour difficulties, we must start to put our house in order. Fuel and labour are going up in price all over the world. The relation of labour to the general scheme of production is changing, and generating more or less friction in the process, and the successful competitors will be those who have tackled the problem of spelter production most radically and with least regard to hampering tradition." Wise words these.

Another instance of the value to the mineral industry of scientific research of possible far-reaching results may be mentioned. Mr. Picard, in his admirable presidential address to the Institution of Mining and Metallurgy in 1919, covering a wide survey of recent metallurgical progress, said:—"In the province of general metallurgy the increasing use of the Cottrell process deserves special mention. As an example of painstaking research in developing a practical process from long known, but unused, scientific fact it has few equals. We have to go back to 1870, to the work of Tyndall, for the first disclosure of the phenomenon on which the process is based. This was further examined by Frankland, Lord Rayleigh, and Oliver Lodge; but for the useful application of the principles involved we had to wait for Dr. Cottrell. He first applied the method to depositing sulphuric acid produced in the contact process, and it is still being used for this purpose. It is satisfactory to report that the merits of the invention have been recognised in this country, the first plant to be erected here in 1917 being at one of the Government acid plants. It is also in use here for the precipitation of fumes from metallurgical works, following established practice in

America; its further application in this country seems certain. The advantages of the process are far-reaching; not only are valuable products recovered, but agriculture in the neighbourhood of the operations is saved from serious damage."

The Cottrell electrostatic recovery process of flue-dust and furnaces consists, as you are doubtless aware, in separating solid and liquid substances from gases in which they are held in suspension and electrically precipitating them.

There are many more fields of research on minerals which I should have liked to discuss had time permitted, such, for instance, as the extraction of aluminium from clays and from the felspar labradorite; the possible utilisation of magnesia cement for the protection of mine timber; the use of ferro-boron in making remarkably strong and tough steels; the possibility of extracting on a commercial scale potash from orthoclase felspar; the cheapening of the production of thorium nitrate from monazite—large residues of cerium compounds are obtained as a by-product, formerly regarded as useless, but now used for supplying the cerium required in the manufacture of the alloy ferro-cerium used in sparking devices—and so on. But all minerals present a field for research, and time does not permit my passing these fields in review. The few instances I have given have been selected with the view of emphasising the point I started off with, namely, that scientific research is one of the factors, and an important one at that, necessary to the development of the mineral industries and to our commercial prosperity. Much more extensive research work is necessary if we are to take full advantage of our mineral resources (with which a bountiful Providence has provided us) by rendering available ores and products therefrom which cannot now be used, and extending the use of those already in commercial consumption and producing them more cheaply.

How should research be organised and carried out? Empirical investigations must be based upon a scientific foundation if they are to be of ultimate and practical value. It has, however, been well said that if an investigator does not possess the inventive faculty as well as the purely scientific, the value of the work is apt to be largely lost. The discovery of new facts or principles is one thing, and is a characteristic of the academic type of mind, whereas the discovery of new uses for such facts or principles is another thing, and is typical of the commercial mind.

In this work of research the universities are peculiarly fitted to take an important, a leading, part. The research should not necessarily be pursued along definite lines with a definite object in view; the great discoveries were not made in that way. The Department of Scientific and Industrial Research might well endow university scientific research on chemical, metallurgical, and engineering work, supervising and co-ordinating and publishing the results. Effort is largely commensurate to the prize offered, and the discoverer should be rewarded for his labour and genius; but that would be a matter easy of arrangement. A certain amount of overlapping in scientific work is not inadvisable, but the Department would see to it that there was not undue overlapping. I offer the suggestion for what it is worth. Research associations undoubtedly perform useful, even highly valuable, functions, but the wind of science bloweth where it listeth, and the time is ripe for a realisation of the fact that scientific research cannot profitably be hampered by restrictions confining the efforts of those who are employed therein. It is of the essence of research that it should be free and untrammelled.

The Imperial Mineral Resources Bureau is not a

Bureau for research, as research is ordinarily understood, but owing to the nature and extent of the machinery which it has at its disposal, including its corresponding members throughout the Dominions and Colonies, its technical advisory committees—active bodies comprising some 151 members, who are among the leading authorities on the respective minerals and the industries connected therewith—it is

in an exceptional position for disseminating suggestions, shaping problems to which they give rise, and carrying out the necessary preliminary surveys, without which it would be difficult to advise as to whether a problem should be brought before organisations such, for instance, as the Department of Scientific and Industrial Research, the province of which is the carrying out of research.

The Genetics of Sex.

By PROF. R. RUGGLES GATES.

THE investigation of the chromosomes in a large number of insects and other animals has shown that the so-called X- and Y-chromosomes furnish a mechanical basis for the determination of sex in the fertilised egg, its inheritance in later generations, and the usual occurrence of approximate equality of the two sexes when one of them is heterozygous (XY or XO). The fundamental character of this relation between the X- and Y-chromosomes and sex is now generally admitted. It would appear that the difference in the chromosome content of the nuclei in the two sexes affects the metabolism during development in such a way as to produce one sex or the other, and in some groups to affect the secondary sexual characters as well. Combined cytological and breeding investigations have shown further that in most insects and mammals, including man, the male is the heterozygous sex, while in the Lepidoptera and birds the female is heterozygous.

Recent work on the subject of sex in animals accepts this situation, and is building upon it a further analysis of sex-differences. The most active lines of work have been (1) in connection with the discovery and interpretation of intersexes in various animals and plants, and (2) in the explanation of the departures from equality in the numbers of the sexes under a variety of conditions, normal or experimental. It is now clear that these results do not negative a chromosome hypothesis of the fundamental distinction between the sexes, at least in animals, but rather supplement it in an important way. Sex intergrades have been studied by Goldschmidt in the Gipsy moth, by Banta in *Daphnia*, and by Sturtevant and others in *Drosophila*; also in plants there have been the studies of intersexes in *Mercurialis* by Yampolsky and in *Plantago* by Bartlett and others. These investigations are still in progress, and it is only necessary to say that they are not out of harmony with a chromosome hypothesis of the origin of the sex-differences, although the situation in plants remains to be cleared up.

Of more immediate interest here are the cases where one of the sexes preponderates. Mr. Julian Huxley (see reference in NATURE, March 24, p. 116) has recently shown how in the millions fish (*Girardinus poeciloides*) a great preponderance of females, followed by a lesser preponderance of males, and finally by equality of the sex-ratio, can be best explained by assuming that the chromosome-constitution of the individual has been temporarily overridden by external influences. The important work of Riddle in controlling the sexes in pigeons may ultimately receive a similar explanation.

In an article by Mr. Alan S. Parkes (*Science Progress*, April, 1921) the author has applied somewhat similar conceptions to the explanation of the well-known departures from equality of the sex-ratios in man. The statistics from the reports of the Registrar-General, 1838-1914, show an average for this period

of 1040 males to 1000 females. There is a similar preponderance of male births in most parts of the world, but in a few regions females preponderate. It is also a remarkable fact that fluctuation in the proportion of male births follows closely the rise and fall in the price of food. Statistics appear to show further a remarkable rise in the proportion of male births throughout Europe during the war, and it is suggested that war conditions were "in some obscure way beneficial to the welfare of the Y-gametes." That racial differences in the sex-ratio exist is shown by comparing Jews with Christians; it appears that the former in all countries show a greater excess of male births, while the crossing of races is also known to disturb the sex-ratios.

From a study of a number of genealogies of British families Mr. Parkes finds that families occur in which the preponderance of males is much greater than 1040:1000, and that this condition is inherited through the male, some strongly male-bearing strains producing more than 58 per cent. in excess of the above frequency considered as the normal.

A new type of inheritance of secondary sexual characters has recently been discovered by Schmidt (*C. r. Trav. Lab. Carlsberg*, vol. xiv., No. 8) in the fish *Lebistes reticulatus* from Trinidad. He shows that the inheritance of a black patch on the dorsal fin of the males in one race is transmitted exclusively from male parent to male offspring, never appearing in the female line at all. This is explained by assuming that the spot is determined by the Y-chromosome, for it is distributed in inheritance as the Y-chromosome is distributed. Hitherto in all cases investigated the Y-chromosome has appeared to be inactive in inheritance, the only evidence against this being the fact that males of *Drosophila* which lack it are sterile. The chromosomes of *Lebistes reticulatus* are now being investigated.

On the basis of this result of Schmidt, Castle (*Science*, April 8, p. 339) has built up an interesting speculation concerning the origin and relationships of the various types of sex-determining chromosomes. Briefly, his suggestion is that the X-chromosome was originally a cytoplasmic body handed on exclusively through the egg, like a plastid, and determining the female condition by its presence. This becomes included in the egg nucleus and is duplicated by splitting, thus giving rise to the condition XX in females and XO in males. If it does not split, a Y element may "develop" as its synaptic mate in the egg, passing later into male offspring, and, through non-disjunction (as in *Drosophila*), ultimately producing YY males which are assumed to be viable; they would give rise, as in *Abraxas*, to the condition in which the female is the heterozygous sex. In criticism it may be said that there is no cytological evidence of the transformation of a cytoplasmic body into a chromosome, unless the "chromatoid body" of Wilson be such a case. But it occurs in addition to the